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Research Article

Salute to Semyon M. Hertz (1947-2020), an outstanding engineer-radio physicist, his social life and contribution to photosynthetic science

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Abstract

The article is dedicated to the memory of Semyon M. Hertz, a talented radiophysicist engineer and remarkable person who left us prematurely at the age of 74. He devoted most of his scientific activities to biology, primarily phototrophic organisms, using radionuclide substances. The main achievements in the study of photosynthesis made thanks to his physical and mathematical calculations and engineering developments, are described. The ability to overcome difficulties, fortitude, vitality, and optimism of Semyon Hertz were noted.

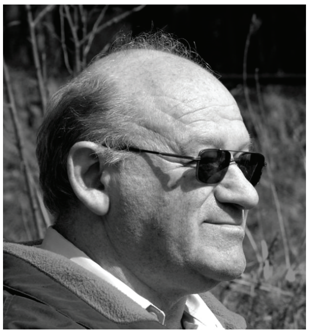

Photo 1: Semyon M. Hertz (Photo from the private collection of Andrey Rudenko, 04 February 2009)

Introduction

On September 25, 2020, at the age of 74 and 6 months, a talented radiophysicist and remarkable person Semyon M. Hertz died prematurely from a massive heart attack. This article briefly recalls his life and scientific path, engineering inventions, and developments, teaching talent, and connections with the scientific community.

Short biography

Semyon M. Hertz lived a truly heroic life. He was born on March 02, 1947, in the city of Odessa, Ukrainian SSR, in the Soviet Union. Semyon grew up as a cheerful, carefree boy, studied well, read a lot, and was an optimist with a great sense of humor. However, while still a schoolboy, Semyon got into a car accident, and as a result of which he lost both legs. After

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many complicated operations, he managed to escape himself from the clutches of death - thanks to the professionalism of Soviet doctors and Semyon's fortitude. But after that everything depended only on him. The gloomy prospect of living in a wheelchair did not suit the young man at all. And Semyon made a firm decision - to learn to walk on prostheses so easily that others would forget or even not know about his disability. The feat of the fighter pilot Hero of the Soviet Union A.P. Maresyev (https://www.nytimes.com/2001/05/19/world/aleksei-maresyev-84-heroic-russian-pilot.html) probably inspired him to make this decision. Thanks to incredible willpower, Semyon managed to ensure that people saw a strong, athletic, always smiling person, limping slightly and using a cane.

In parallel with physical health development, Semyon did not forget about his education and career choice for the future. He graduated with honors from high school and in 1965 entered the M.V. Lomonosov Odessa Technological Institute for Food Industry at the Faculty of Automation and Telemechanics. This faculty did not accept people with disabilities. But Semyon achieved that he was admitted to the entrance exams, and in 5 years of the study showed himself to be the best student on the course. He graduated from the Institute in 1971, also with honors, having received a specialty, very rare in the USSR at that time, in dosimetry and protection. After graduating from the Institute, Semyon married a beautiful girl Tatyana Ivanovna Rudenko, whom he met at the Faculty of Biology of Odessa State University. Soon they had a son, Andrey.

For some time, Semyon worked in the food industry but realized that this was not his place. The fact is that his wife Tatyana, being a keen biologist and an excellent popularizer, told Semyon amazing things about wildlife and its evolution on Earth. Probably, she contributed not only to the expansion of Semyon's scientific horizons, but also inspired him to use his professional knowledge and skills in the field of physics, mathematics, engineering, and, most importantly, radioisotope research methods in biological sciences, primarily in ecology, physiology, and biochemistry of phototrophic organisms. Over the next decades, Hertz never regretted that he devoted his scientific life to the study of the functioning of living biological systems.

Scientific and organizational skills of Semyon Hertz

In 1973, Hertz and his family moved to a permanent place of residence in Pushchino, Moscow Region, the Scientific Center for Biological Research of the USSR Academy of Sciences, where his wife received a research vacancy at the recently organized Institute of Photosynthesis. In the same year, one of the discoverers of cooperative photosynthesis (C_4 photosynthesis) Yuri Karpilov (see about Karpilov: [1-3]) who was a head of the Carbon Metabolism Laboratory in this Institute recruited Hertz to the team of his Laboratory as a research engineer (Photo 2, see also photo 12.12 in the article [3]). In this field, Semyon showed himself to be a hardworking, erudite employee, capable of independent scientific, organizational, and creative work. Soon Karpilov offered Hertz to head the Radionuclide Group for the development of isotopic methods about the Laboratory's topics. Professor Karpilov was sure that Hertz was more suitable for this position than other candidates since he had not only a special education in the use of radioactive isotopes in various fields of science and technology but also practical work experience.

Accepting Karpilov's offer, Hertz, first of all, took up the organizational work: he bought the necessary reagents, materials, and modern measuring equipment, organized premises for storing radioactive compounds and biological objects "labeled" with these compounds, prepared a "heap" of documentation for obtaining a license to use radioisotopes

Photo 2: Carbon Metabolism Laboratory (1972 – 1977) of the Institute of Photosynthesis of the USSR Academy of Sciences (now the Institute of Basic Biological Problems of the Russian Academy of Sciences).
Note: *From left to right:* 1st *row* – Raisa Kartasheva, Yuri Karpilov, Semyon Hertz; 2nd *row* – Aleksandr Maslov, Valery Lyubimov, Lyudmila Belobrodskaya, Liya Oparina; 3rd *row* – Aleksandr Kuzmin, Raisa Karpova, Karl Biel, and Irina Novitskaya (Photo from the archive of the Institute of Basic Biological Problems, 1975).

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in scientific research, such as ^3H, ^{14}C, ^{32}P, ^{35}S, and others. Then, having trained his employees in the intricacies of making objects, working with measuring instruments, and safety precautions, Semyon officially opened the Radionuclide Group for the employees of the Carbon Metabolism Laboratory.

Thanks to Semyon's talent to popularize the possibilities of using radioisotope methods in biology, employees of other laboratories of the Institute soon became to show interest in working together with Hertz's Group. Later, the Radionuclide Cabinet became an independent scientific and technical unit of our Institute, and over the next 40-odd years, joint scientific research was carried out with employees from other laboratories of the Institute, other Institutes of the Pushchino Scientific Center for Biological Research, several scientific organizations of the Soviet Union, and then countries of the former Soviet Union and even foreign countries, such as the United States and Israel.

For decades, Hertz improved the methods of using radioactive isotopes in biological research, personally participated in the development of technical means for solving several scientific problems, and taught and advised scientific and scientific-technical personnel to work with radioactive substances, scrupulously prepared the necessary documentation for reports to higher supervisory organizations. We emphasize that Semyon, as a super-professional in this sphere, was often asked for advice not only from neighboring Institutes of the Pushchino Scientific Center for Biological Research but also from other scientific institutions in the country.

The fact is that the use of radioisotopes in the USSR, and then in Russia, is under constant strict state control. Bureaucratic organizations at various levels vigilantly monitor the rational and safe use of radioisotopes and, especially, the disposal of radioactive residues from the production of radioisotopes or experiments with them by established norms and instructions. This is very important and valuable for the environment and public health. However, for the use of even very small amounts of radioisotopes for scientific purposes, scientific organizations must have special premises and equipment, a staff of specially trained employees, and, most importantly, those responsible for radiation safety, who, together with the head of the radionuclide office, make up the reporting supplementation.

We consider it important to note that for more than four decades the Radionuclide Cabinet led by Semyon Hertz never brought penalties to the Institute from the State supervision authorities. One of us (KB), who has been in charge of radiation safety at the Institute for 20+ years, knows how difficult it is in practice to comply with the regulatory requirements of supervisory organizations. In this regard, Semyon was an extremely responsible person, capable of positively solving serious problems arising in the planning and implementation of scientific research using radioactive substances.

Scientific and engineering contribution of S. Hertz

As mentioned above, in 1973 Hertz began his engineering, technical and scientific activities in the Carbon Metabolism Laboratory of the Institute of Photosynthesis of the USSR Academy of Sciences (now the Institute of Basic Biological Problems of the Russian Academy of Sciences) (Photo 3). Subsequently, having separated into an independent unit, he, despite being busy with new responsibilities, continued cooperation and friendship with our laboratory. Creative interaction with Hertz became so familiar to the team that we considered him a "full-fledged" member of our laboratory. Hertz took part in the life of the Laboratory both in the planning and implementation of scientific tasks and in informal seminars, often held by us in nature, that is, in the beautiful forest surrounding the city of Pushchino, or on the banks of the Oka River (view of nature and Pushchino, see Photo 4).

The main goal of our Laboratory was to study the features of photosynthetic carbon metabolism in various phototrophic

Photo **3:** The staff of the Carbon Metabolism Laboratory of the Institute of Photosynthesis of the USSR Academy of Sciences.
Note: *From left to right:* 1st *row* - Raisa Karpova, Valentina Polyakova, Aleksandr Maslov, Liya Oparina; 2nd *row* - Aleksandr Kuzmin, Valery Lyubimov, Karl Biel and Semyon Hertz. Not shown: Yuri Karpilov (Head of the Laboratory), Raisa Kartasheva, Irina Novitskaya, and Lyudmila Belobrodskaya (Photo from the collection of Karl Biel, 1973).

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Photo 4: Pushchino (Biological Campus of the Russian Academy of Sciences) in Moscow Region, Russian Federation. Science City can be seen on the horizon; in the foreground is the Oka River (Photo by VN Grishin).

organisms of different taxonomic groups. 85-90% of our investigations were related to the use of radioactive isotopes, primarily carbon. At the same time, the use of standard serial equipment was often insufficient to answer scientific questions arising in the course of work. Therefore, most of the experiments were performed with technical devices that we developed ourselves. This creative but time-consuming approach has certain advantages that often lead to unique scientific results. Naturally, we constantly needed a colleague capable of inventing and creating the necessary equipment or modifications for serial devices. This person for us was Semyon Hertz, who possessed not only engineering and design talent, but also a sincere interest in a unique biological process - photosynthesis.

When a physicist and engineer by training applies his knowledge in biology, it usually yields remarkable results. For example, according to Hertz's idea and his drawings, a "closed-loop" exposure chamber was constructed. At first glance, a simple, ingeniously designed sluice device made it possible to inject radioactive carbon (^{14}C) into a photosynthetic object in the shortest time intervals (from 0.2-0.5 seconds to minutes or more), followed by instantaneous fixation of the material. And all this complies with safety rules for the operator and others.

With the help of this handmade sluice equipment, we carried out pioneering studies to elucidate carbon metabolism in the dark and in the light in hundreds of plant and algae species inhabiting the contrasting ecological regions of the USSR and abroad.

Naturally, the subsequent processing of a large volume of ^{14}C-tagged material (tens of hundreds of variants in just one expedition) required serial flow technology to identify ^{14}C-products. For this purpose, we originally used two-dimensional ascending paper chromatography, as proposed by Prof. Andrew Benson in the 1950s [4], see also [5]. However, the industrial chromatographic chambers we had in the Laboratory did not meet our new needs; it was necessary to make their significant reconstruction. The project of constructing easily transportable chromatographic chambers was discussed with Semyon and implemented according to his drawings. Implementation of Hertz's ideas made it possible to carry out in-line two-dimensional ascending separation of radioactive samples deposited on chromatographic paper and at the same time significantly save chemical reagents, chromatographic paper, and X-ray film, which were lacking in the Soviet Union.

Thus, the combined use of the "closed-loop" exposure chamber and chromatographic vessels made according to Semyon's projects allows for obtaining reliable results not only in laboratory conditions but also in the field.

Below are the most significant of the many of our studies in which we have used the above-noted equipment. In particular, when researching:

- ❖ composition of products of photosynthesis in green, brown, and red algae-macrophytes, as well as transport and redistribution of ^{14}C-photoassimilates within thalli of brown alga *Sargassum pallidum* inhabiting the Japanese Sea ([6-12] etc.; Vladivostok, Russian Federation);
- ❖ carbon metabolism of photosynthesis and dark fixation of CO2 in the native plant species of the Kara-Kum desert ([10,11,13-16] etc.; Ashkhabad, Turkmen SSR);

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- features of photosynthesis of salt-tolerant higher plants inhabiting the Black Sea coast ([17] in a 60+ km shore walking expedition between Odessa and Belgorod-Dnestrovsk, Ukrainian SSR);
- transport and metabolization of ^{14}C-U-sucrose by ears of wheat in the climatic chambers of the Odessa Breeding and Genetic Institute ([18-21] Odessa, Ukrainian SSR);
- phototrophic symbionts of Baikal freshwater sponges ([22] Irkutsk, Russian Federation).

In several expeditions, Hertz was directly involved. He showed himself well on these trips. Despite the "physical" problems, Semyon always behaved like an equal, healthy member of the Group. Probably, to some extent, this was helped by the experience acquired by Semyon as a student, when he swam in a kayak on mountain rivers, climbed mountains ... and all this on prostheses ...

We have also successfully and fruitfully used engineering developments and scientific and technical ideas of Semyon Hertz in foreign expeditions and business trips. In particular, in the field conditions of the Indian Ocean [23-28] and the Red Sea, in the Interuniversity Institute of Marine Sciences in Eilat, in collaboration with Prof. Zvy Dubinsky, the Life Science Department of the Bar-Ilan University, Ramat Gan, Israel [29-31] in the Laboratory of Prof. Leonard Muscatine at the University of California, Los Angeles, California [32-34] and the Laboratory of Prof. John Nishio at the University of Wyoming, Laramie, Wyoming [35].

It is noteworthy that in the Soviet-American marine expedition to the Indian Ocean, Seychelles [23-28] Prof. Andrew A. Benson, the great American scientist who pioneered the $^{14}CO_2$ / $H^{14}CO_3$ chromatography [4,5,36] initially skeptical referred to our improvements to his technology. But when we got the first field results, he was delighted. Moreover, when one of us (KB) applied a similar technology under the stationary conditions of the University of California, Los Angeles [32,34], Andrew Benson unconditionally accepted our modifications of his chromatographic method as the most perfect achievement, created thanks to unconventional ideas and talent of Semyon Hertz.

Another example of Semyon's engineering and design talent. To get a native thin slice of leaves, Hertz modified a microvibrotome invented by Dr. Vladimir G. Skupchenko [37] for animal tissues. This microvibrotome made it possible to obtain serial cross-sections and, what is especially important, - paradermal (along with the leaf plate) sections of native leaves of higher plants with a thickness of 5-25 microns and/or thicker. As a result, having made for the first time serial paradermal sections of the mesophytic leaf, *Spinacia oleracea*, we were able to adequately assess several morphological and functional characteristics of different types of cells and tissues within the leaf plate [35,38].

Hertz's participation in joint scientific research

Hertz actively collaborated, in addition to our Institute, with scientists from other institutes of the Pushchino Scientific Center for Biological Research of the USSR Academy of Sciences (later PSC RAS), such as the Research Computing Center, Institute of Biological Physics, Institute of Agrochemistry and Soil Science, Institute of Biochemistry and Physiology of Microorganisms, as well as with the Institute of Biology of the Komi branch of the USSR Academy of Sciences (Syktyvkar, Russian Federation), the Institute of Marine Biology of the Far East Scientific Center of the USSR Academy of Sciences (Vladivostok) and the Odessa Plant Breeding and Genetics Institute VASKhNIL (Odessa, Ukrainian SSR).

For many decades, Hertz generously shared with colleagues his innovative ideas and specific technical solutions in various fields of biological science, for example, plant physiology, microbiology, agrochemistry, and soil science [39]. At the same time, often colleagues who used the author's technique and methods of Hertz, as well as his help in mathematical processing and analysis of the results obtained, "forgot" to mention his name in scientific publications. It is noteworthy that Semyon did not care at all ... And this was the whole Hertz: he was always glad that his idea turned out to be correct and found its embodiment!

Works that could not have seen the light without Hertz's direct participation

In this memory, we decided to mark some of them.

Math modeling and chloroplast fluctuations. Mathematical modeling and mathematical analysis, then rarely used in biochemistry and physiology of plants, were brought to us by Simeon. In one of Hertz's early works in this direction [40], dedicated to modeling the proteolytic properties of a polyelectrolyte with an arbitrary set of stepwise dissociation constants, it was shown that in some cases (e.g., in the study of biological membranes and their components), you can use simplified variants of disintegration.

A phenomenological model of slow changes photophosphorylation in the ontogeny of grain crops was also described with the participation of Semyon [41,42].

In another series of experiments [43-46], Semyon, together with Tatyana Rudenko and colleagues, first proposed to clarify the issue of the role of oscillatory movements of cell organelles, in particular chloroplasts, in the general metabolism of photosynthetic cells, tissues, and the whole plants. For this purpose, the authors used microphotography and mathematical modeling.

Chlamydomonas mutants. In our Group, Semyon Hertz was responsible for the use of *Chlamydomonas* pigment mutants in the early 1980s. Under his leadership and with his direct participation, a series of experiments were carried out to study the features of photosynthetic carbon metabolism in *Chlamydomonas reinhardtii* mutants with inactive photosystem 1 (PS-1) and photosystem 2 (PS-2) from the collection of Dr. Sci. Vladimir G. Ladygin [47]. It was found [48-50] that a mutant lacking PS-1 is capable of light-dependent oxygen uptake associated with its reduction and participation in this process of endogenous cell connections. The use of the ^{14}C-radioisotope

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approach showed that in the wild strain *C. reinhardtii* in the dark and mutants with inactive PS-1, PS-2, and both photosystems in the dark and in the light during the assimilation of $^{14}CO_2$, the ^{14}C-radioactive label appears in 3-phosphoglyceric acid and phosphoric esters of sugars, the pools of which decrease as the endogenous substrates accumulated by cells during the period of mixotrophic nutrition are depleted. The carbon flux through the pools of these compounds does not exceed 5% of the rate of CO_2 dark fixation. Based on the totality of the results obtained using the O_2-electrode and ^{14}C-isotope techniques, it was suggested that the energy equivalents (reducing agent and ATP) required for the synthesis of phosphorus esters of sugars can be transported to the chloroplast from the cytoplasm and/or mitochondria. This hypothesis received experimental confirmation in the same years in Prof. Tarchevsky's Laboratory in Kazan. Probably, Igor A. Tarchevsky and his colleague Tatyana M. Konyukhova [51] were the first to show *in vitro* that under extreme conditions mitochondria can supply chloroplasts not only with carbon dioxide released during respiration but also ATP. Later, the idea of the participation of mitochondria in photosynthetic carbon metabolism and protection of photosynthesis from photoinhibition was developed in detail in several works (see cit. Literature in [52]).

Linuron and the yield of different wheat genotypes. Contamination of soil and agricultural products with residues of long-used herbicides, such as phenylurea derivatives, for example, linuron, diuron, monuron, etc. in low concentrations makes it relevant to clarify the issue of their effects on the life processes of cultivated species. Earlier, [18,19] showed that the treatment of cereals with low concentrations of linuron leads to an increase in the mass and protein content of the grain, while the intensity of photosynthesis of ears and flag leaves decreases.

According to our opinion, the increase in grain fulfillment observed in this case was associated with the stimulation of the flow of metabolites from other organs to the ear, caused by the inactivation of photosynthesis of green parts of the plant under the influence of the herbicide.

To clarify the relationship between the effect of linuron on photosynthesis and the attraction of metabolites to the ear, we proposed to Hertz to construct a special design and conduct a model experiment in which wheat ears cut below the internodes of the flag leaf could be incubated in a solution of ^{14}C-U-sucrose in the presence of linuron on the modes. Simultaneously with that, it was necessary to study the dependence of the effects on the vegetation stage and varietal specifics.

A model experiment with uniformly labeled ^{14}C-U-sucrose, carried out jointly with Hertz, fully confirmed the correctness of the above hypothesis [18-21] and additionally showed that: (a) the attraction of photo-assimilates by ripening ears of wheat occurs in the oscillatory mode of circumlunar endogenous rhythms; (b) low concentrations of linuron cause an increase in the amplitude of these fluctuations under lighting conditions; (c) the dependence of the observed effect on lighting indicates its relationship with the effect of the herbicide on photosynthesis of phototrophic organs of plants, and (d) the intensive wheat variety is more sensitive to linuron than the extensive one.

Practically important conclusions were also made about the advisability of using low concentrations of phenylurea derivatives in large-scale production of cereals as crop formation regulators:

- ✓ a positive effect can be obtained only with the right choice of exposure time and culture genotype;
- ✓ at the same time, it is necessary to ensure complete removal of the herbicide from the nutrient medium of plants at subsequent stages of the growing season, which is possible only in the closed ground, phytotronic complexes, and closed trophic systems;
- ✓ in open production areas, the use of these compounds even in regulatory concentrations, firstly, will not allow a short-term impact on the required stage of maturation and, secondly, will lead to long-term soil contamination.

It is also important to bear in mind that subsequent sowing in areas contaminated with herbicide will expose plants to the herbicide in the early stages of ontogenesis when intensive photosynthesis is required for active vegetative growth. Therefore, it is preferable to grow homeostatic varieties of cereals that are weakly sensitive to the action of herbicides on areas treated with herbicide.

Photorespiration, glycolysis, and photosynthesis. The questions of the interaction of the processes of photosynthesis, photorespiration, and glycolysis acquired particular relevance for researchers in the 1960s-80s in connection with an attempt to "quickly" solve the problem of managing the production process of economically important crops. This line of research has also developed in our Laboratory. A special collection of works ("The Mechanism of Photorespiration and Its Features in Plants of Different Types", 1978, edited by Karpilov and Romanova) was devoted to the mechanism of photorespiration and its features in different types of higher plants. The book contented mainly on the materials of the Carbon Metabolism Laboratory of the Institute of Photosynthesis, USSR Academy of Sciences.

Due to the commonality of several products involved in the processes of photosynthesis, respiration, glycolysis, and other biochemical pathways of an autotrophic cell, we decided to conduct a comprehensive study using biochemical, biophysical, and radioisotope methods on phototrophic objects with different levels of organization of the photosynthetic apparatus. Semyon Hertz was an active co-author of one of these works. In particular, in a 97-page work [53] the regulatory role of glycolysis in ensuring the relationship between photosynthetic and photorespiratory metabolisms of a photoautotrophic cell was considered. When studying the metabolism of ^{14}C-compounds, experiments were carried out on the whole C_3 and C_4 plants, discs carved from leaves, separated assimilatory tissues, isolated protoplasts, chloroplasts, and enzymatic extracts using special radioisotope techniques,

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most of which were developed by Semyon. The sequence of introducing labeled carbon into an object in the light and the dark, as proposed by Hertz, as well as a mathematical analysis of the results obtained, made it possible to "identify" the participation of some ^{14}C-compounds, common for several biochemical pathways, in one or another of these pathways.

As a result, the reactions of glycolysis in the assimilatory tissues of C4 plants, the significance of the enolase reaction of glycolysis in the regulation of photosynthetic carbon metabolism, and the effect of photophosphorylation on glycolysis were studied; the possibility of oxidation of ^{14}C-pyruvate in mitochondria in the light and the dependence of this process on glycolysis reactions have been established. Particular attention was paid to elucidating the pathways of alanine metabolism in leaves of different types of plants in an atmosphere devoid of CO2, the metabolic interaction of chloroplasts with the cytoplasm, and the effect of alanine on the composition of photosynthetic products. At the final stage of this complex and multilevel experimental scheme, the role of pyruvate kinase in nonspecific changes in photosynthetic carbon metabolism was elucidated. Ultimately, the work considered the sequence of reactions associated with the carboxylation of phosphoenolpyruvate during CO2 fixation in the dark and the light and proposed a hypothetical scheme of reactions that shunt the activity of pyruvate kinase during glycolysis.

Scientific plans that were not destined to be fulfilled in full. After the closure of the Radionuclide Group, Hertz was transferred to our Research Group as an engineer (Photo 5). At that time, the role of engineering and design developments in our Team naturally increased, as well as the importance of creative specialists in this field. So, Semyon was directly involved in the development of the following scientific directions:

- ✓ to solve several questions about the structure and functioning of photosynthetic membranes using cyanobacteria as model systems [54-56];
- ✓ to study the processes of regulation of plant stress tolerance in natural conditions [57], which typically should be carried out using multivariate statistical analysis;
- ✓ according to our plan, Hertz would also lead the development of an optimal technological solution for large-scale cultivation of unicellular algae to control the rate of life processes and the direction of carbon metabolism of photosynthesis in economically important and commercially profitable species.

However, these plans were not fulfilled in full due to the illness of Semyon Hertz.

Conclusion

The authors of this article are immensely proud of their long-term professional and friendly relations with Semyon M. Hertz, an erudite, highly qualified researcher and a wonderful person. Hertz's premature death is an irreparable loss for everyone who knew him, and the Institute lost a unique colleague capable of solving complex scientific and technical problems. Semyon Hertz was not only a professional engineer, physicist, and mathematician, but also an intelligent advisor and consultant on any complex issues, as he possessed special common sense, broad outlook, knowledge of human psychology, and the ability to calculate moves several steps ahead. And even, Semyon, to some extent, was able to see non-obvious connections and contradictions, that is, he had the gift of a seer ... It should also be added that Hertz was not at all a conflict person. For many decades of working with him, we have never seen him resolve official or personal controversial

Photo 5: Semyon Hertz is a member of the Group of Ecology and Physiology of Phototrophic Organisms of the Institute of Basic Biological Problems of the Russian Academy of Sciences.
Note: *From left to right:* 1st *row* - Galina Nazarova, Irina Fomina, Tamara Balakhnina; 2nd *row* - Simon Hertz, Anatoly Kosobryukhov, Valery Lyubimov, Karl Biel. The following employees are not in the photo: Vladimir Kreslavski, Vladimir Matichenkov, Anatoly Ivanov, Nadezhda Shabnova (Photo from the collection of Karl Biel, 2005).

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issues aggressively, "in a raised voice" ... He always did it only in a friendly and humorous manner.

In conclusion, let us say about one more feature of Hertz's character. At all times, our Institute was visited by guests from domestic and foreign scientific and educational organizations. Many of them were interested in the technology of using radioisotopes in biology and biotechnology. In these cases, it was impossible to find a better consultant than Hertz.

Usually, Semyon told the guests in an accessible and entertaining way about the radioisotope technologies used at the Institute and existing to the protection against the negative effects of radioactive substances on the health of staff. As a result, he dispelled the often-unfounded fears of guests about the dangers of working with radioisotopes. The listeners (see, for example, Photo 6) developed a very respectful and good attitude toward Semyon as an intelligent, qualified, and interesting interlocutor, and they automatically transferred this opinion to the whole Institute, as such ...

Postscript

It has long been known that collaboration between biologists and representatives of the exact sciences (physics, mathematics, and chemistry) is one of the most promising opportunities for gaining new knowledge about living systems. Such cooperation makes it possible to more effectively, deeply, and quickly reveal different sides of the laws of living nature, predict the possibility of optimizing the development of organisms, and directed regulation of bioproduction, for example, plant species important for humans. The visual and brilliant collaboration (40+ years) of Semyon Hertz with the specialists in the field of photochemistry, physiology, and biochemistry of plants, ecology, botany, microbiology, agrochemistry, and soil science can serve as a clear illustration of this ...

Photo **6:** Semyon Hertz (right) and Irina Fomina (middle) making tur for American scientist Dr. James L. Bedell (left), Executive Vice-President at Biosphere Systems International Foundation, Tucson, Arizona 85710, USA, in the Institute of Basic Biological Problems of the Russian Academy of Sciences in Pushchino Moscow Region (Photo from collection of Karl Biel, 2005).

It will be difficult for us if at all possible, to find a person with such knowledge, disinterestedness, openness, and immense scientific curiosity that Semyon Hertz possessed.

Acknowledgments

The authors are grateful to Semyon Hertz's wife Tatiana I. Rudenko and his son Andrey S. Rudenko for the information provided and several photographs from Semyon's private life.

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